Observation of Snow Properties, Meteorological Forcing and Brightness Temperature Data at the Local Scale Observation Site during the Cold Land Processes Field Experiment and the Application to a Dense Media Radiative Transfer Model

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This paper introduces radiometer, snow pack properties and meteorological forcing data observation during the winter season `02/`03 in Fraser, Colorado, USA. The observation was part of the NASA Cold Land Processes Field Experiment (CLPX) at the Local Scale Observation Site (LSOS). Apart from continuous observation of meteorological data, which can be used as forcing data sets for physical based snow models, intensive ground based passive microwave observations have been implemented during the winter season. Furthermore regular observations of the snow pit properties have been conducted, including the snow density and snow grain size profiles. The observed data set provides the possibility to evaluate and improve radiative transfer models for snow and good modeling results have been achieved using the dense media radiative transfer theory. All data will be released to the public on October 1, 2004 and is available from the website of the National Snow and Ice data center.

1. Introduction

Due to its high albedo and thermal insulation, snow plays an important role in the global energy and water balance, e.g. it changes the runoff characteristics of a catchment and influences the soil moisture and evaporation[1].

Up to 53% of the northern hemisphere and up to 44% of the world land mass can be covered with snow at any given time[2]. World wide one third of the water used for irrigation is temporarily stored as snow[3]. In the Rocky Mountains 90% of the runoff is from snow melt and 75% of total annual precipitation is solid[1].

Passive microwave satellite observation (brightness temperature) can be used to monitor the snow depth or water equivalent (SWE) and the snow state (dry/wet)[4]. The objective of the field work in Fraser was to create a detailed data set of snow radiometer observation in combination with the actual snow pack state in order to evaluate and improve current radiative transfer models for snow. A possible application for radiative transfer models for snow is the assimilation of satellite brightness temperature observations into land-surface schemes or snow models.

(1) CLPX and LSOS

The objective of the Cold Land Processes Field Experiment was to improve our understanding of the terrestrial cryosphere[5]. The CLPX followed a multi-sensor and multi-scale approach, to improve our possibilities to understand cold land process at
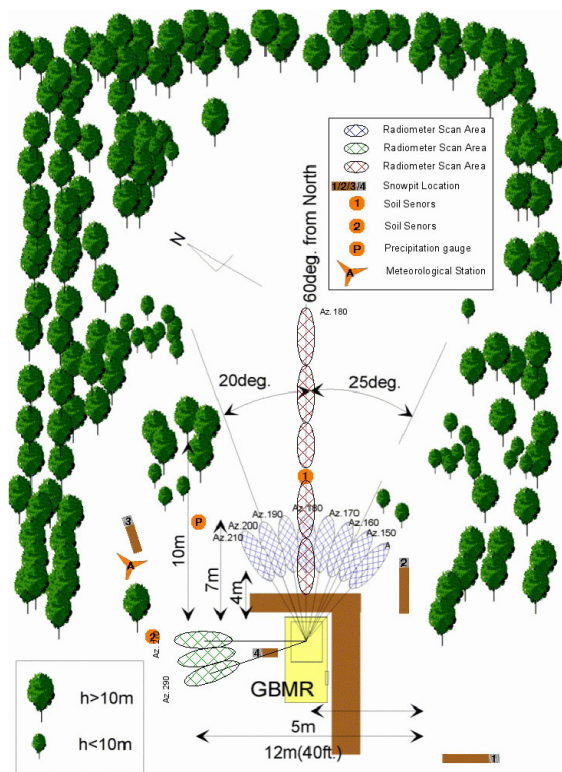
Fig. 2: Overview of Instrument Set-Up

local scale to larger scales. During the CLPX, four intensive field observations (IOP) have been implemented in February (dry snow) and March (wet snow) 2002 and 2003.

Our observations have been implemented at the LSOS, which was the smallest of all study sites within the CLPX. The LSOS was located within the Fraser Experimental Forest.

Within the CLPX the LSOS was used to implement very detailed observation of the local snow conditions, soil properties, vegetation and energy balance characteristics, which allow the investigation of scaling issues between ground based observations and airborne-/satellite-based sensors. Janet et. al.[6] provides a complete overview of all data collected during the CLPX IOPs at the LSOS.

(2) Field Experiment
The main target of the field work was the observation of the brightness temperature of a seasonal snow pack in combination with the structural properties of the snow cover.

Apart from the observed snow characteristics, continuous observations of the meteorological forcing data have been implemented.

(a) Site Overview
Fig. 1 provides an overview of the instrument set-up. The radiometer system has been installed at the edge of a large clearing within the forest area of the Experimental Forest. Three different scan areas have been selected to observe the snow brightness temperature. The location for snowpit observations and the weather station have been selected, so that they are close to the radiometer footprints. Furthermore also the meteorological data and the soil probes are located close to the scan areas.

Fig. 1: GBMR-7 at the LSOS

(b) Ground Based Microwave Radiometer
The ground based brightness temperature observations have been implemented by means of the 7 channel Ground Based Microwave Radiometer (GBMR-7). The GBMR-7 is a dual polarization, multi frequency passive microwave radiometer, which observes the brightness temperature at 18.7, 23.8, 36.5 and 89.0 GHz. The radiometer was developed to provide similar frequencies as the Advanced Microwave Scanning Radiometer (AMSR and AMSR-E) on board of Terra and Aqua.

The sensor was developed for environmental research and is designed for extreme outdoor conditions. The temperature range within the radiometer can operate is -30°C to +40°C, this wide temperature range is achieved by encapsulation of all critical parts of the receiver in a thermal stabilized box[7].

Fig. 2 provides a picture of the radiometer at the LSOS. The radiometer box contains the receiver electronic, which is placed on an accurate positioning system (azimuth: 0° to 360°, elevation: ±90°). The positioner enables the system to exactly return to previously scanned areas.

4. Discussion & Outlook

Due to the combined observation of structural snow pack properties and the snow brightness temperature data, the data set will be useful to evaluate current radiative transfer models for snow and help to identify their limitations.

The results achieved using the DMRT theory, show the possibility to use this approach to model the radiometer brightness temperature using observed data in the field, still several problems have been identified, which need to be addressed.

Furthermore the observed meteorological forcing data can be used for snow modeling and will help to develop relationships between the observed and modeled snow grains and their representation in current radiative transfer model for snow, which is e.g. necessary for data assimilation of satellite observations into land-surface schemes or snow models.

All data[15] will be released to the public on October 1, 2004 and is available from the website of the NSIDC (http://www.nsidc.org/data/clpx).